EQUIVALENT CIRCUITS OF RELUCTANCE MACHINES

BY

CHI-YUNG LIN

B.S., National Central University, China, 1942
M.S., Oregon State College, 1948

AN ABSTRACT OF A THESIS

SUBMITTED IN PARTIAL FULFILLMENT OF THE REQUIREMENTS
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In this thesis, an attempt has been made to investigate the nature of reluctance torque, and to show that the application of equivalent circuits is very valuable in analyzing the steady state operation of alternating current machines, in particular, the reluctance machines. In order to express the reluctance torque in terms of machine dimensions and the number of armature conductors, a simplifying assumption of uniform air gap at effective lengths δ_1 and δ_2 has been made. For a given machine, this assumption may be replaced by its actual air gap permeance distribution. The torque equations finally derived will not only furnish some information useful in designing reluctance machines, but also will indicate certain general operating features regarding them.

Equivalent circuits have been developed upon the recurrent voltage equations mathematically derived for single-phase, symmetrical polyphase, and unsymmetrical two-phase reluctance machines under symmetrical and unsymmetrical synchronous operation. These circuits are constructed (a) directly at the machine terminals, (b) under the general assumption of non-sinusoidal applied voltages, (c) under the assumption of having zero and second harmonic air gap permeance distribution, but with the possible extension of considering the influence of higher harmonic permeance distribution, (d) with and without the consideration of the presence of incomplete damper windings. For single-phase and symmetrical polyphase reluctance machines, these equivalent circuits are given in both singly infinite ladder network and doubly infinite ladder network forms. For unsymmetrical two-phase reluctance machines, these equivalent circuits are, in general, presented in nodal schemes to give clarity in appearance.

By properly determining the machine constants and introducing the excitation voltage, the above equivalent circuits have been applied to the analyses of single-phase and poly-

phase salient pole synchronous machines under normal as well as short circuit operation. Results thus obtained, after simplification, have been found in agreement with those given by previous investigators. The equivalent circuit study is a more general and straightforward approach, and will give more information desired.

It has been shown mathematically and graphically how the mechanical power and, hence, the torque developed are directly measurable in terms of wattmeter readings in the equivalent circuits. Even those equivalent circuits which are primarily developed for finding the "characteristic currents" of reluctance machines, and thus simplifying their performance calculations, may be modified to obtain the possibility of such direct measurement of the mechanical power developed. This feature is especially useful in making a calculating board study of the machine operation.

For machines operated under sinusoidal applied voltages, the equivalent circuits of fundamental frequency are readily deduced. These circuits have been found useful in (a) the complete performance calculations of reluctance machines, and synchronous machines, (b) the direct calculations of pull out characteristics of reluctance machines, and their characteristics when the mechanical power output is given, (c) the developments of circle diagrams of reluctance machines, and current loci of synchronous machines with fixed excitation, (d) the design of reluctance machines, as given also by various examples in the Appendices.

Similar procedures have also been employed to develop the generalized equivalent circuits of reluctance machines under asynchronous operation. The differences between these circuits and those under synchronous operation have been discussed. From these generalized equivalent circuits, the equivalent circuits useful in analyzing the starting performance of salient pole synchronous motors, the asynchronous operation of salient pole machines with excitation, and the symmetrical and unsymmetrical operation of induction machines are deduced, as illustrated by examples.

VITA

Chi-Yung Lin was born on July 5, 1921 in Putien, Fukien, China. He had his elementary school education in the Tung Teh District Primary School and his high school education in the Provincial Putien Middle School, both in Putien, Fukien, China. He entered the National Central University, then in Chungking now in Nanking, China, in August, 1938, and received the degree of Bachelor of Science in Electrical Engineering, with honors, from the same University in July, 1942.

He was appointed an Assistant in charge of the dynamo laboratory of the above named institution in the following September. In July, 1943, he went back to his native province, Fukien, and served as Dean and Teacher of Mathematics and Physics in Chung-Sun High School for more than two and half years. In 1946, he went to Shanghai and was appointed a Lecturer, teaching Electrical Engineering, Heat Power Engineering, and was in charge of the power laboratory in the Shanghai Municipal Institute of Technology. In 1947, he also became an Associate Engineer in the Electrical Engineering Laboratory, National Bureau of Industrial Research, China.

In September, 1947, he came to the United States and studied at Oregon State College under a State Scholarship. Upon receiving the degree of Master of Science in Electrical Engineering in August, 1948, he continued his graduate work in the University of Illinois. He held a University Fellowship in two academic years 1948-1950. He is a member of the American Institute of Electrical Engineers, the Institute of Radio Engineers, and the Phi Kappa Phi Honor Society.

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